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Outbreak of measles in a teenage school population: the need to immunize susceptible adolescents

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SUMMARY

An outbreak of measles occurred in a community school and the surrounding area in Crowborough, East Sussex, UK, from December 1992 to February 1993. There were 96 suspected cases reported: 66 cases among 1673 students at one school and 30 community cases. The majority of suspected cases were in those aged 11–17 (78%), 2 cases occurred in infants < 1 year old and 8 cases in adults aged 18 years or over. Data collected on 60 (91%) of the 66 suspect school cases showed 56 (93%) had an illness which met a case definition of measles. Eighteen had confirmatory IgM measles antibody. Two cases were hospitalized. The local percentage uptake for measles immunization for the school age years affected varied between 64% and 84%. A survey of parents showed that approximately 74% of the students attending the school had a history of measles immunization. The immunization rates reported by parents for children who developed measles was 21%, (29% based on GP records) compared with 77% for those who remained well. Vaccine efficacy was estimated to be 92%. This outbreak, along with others recently reported in older unimmunized children in the UK, reinforces the need for catch-up immunization programmes to reach this susceptible group of adolescents.

INTRODUCTION

Since the introduction of measles vaccine in England and Wales in 1968 and particularly measles, mumps and rubella (MMR) vaccine in 1988, the notification of cases of measles has shown a marked decline. Between 1986 and 1992 the number of cases notified annually to Office of Population Censuses and Surveys (OPCS) fell from 80999 to 10264 [1, 2].

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Table 1. *Vaccination uptake levels for England, S.E. Thames and East Sussex, 1979–85*

Year of birth	Year of vaccination	% Vaccinated		
		England	S.E. Thames	East Sussex
1977	1979	51	44	64
1978	1980	53	46	67
1979	1981	55	50	69
1980	1982	58	55	82
1981	1983	60	58	82
1982	1984	63	60	80
1983	1985	68	66	84

Recently, there has been an upward shift in the age distribution of notifications of measles infection. In the first half of 1991, 6% of cases occurred in children aged 10–14 years, whereas in 1992 15% of cases occurred in this group [2]. Outbreaks have also been reported in older children throughout the UK in recent years. In 1991, 74 cases were identified in Gwynedd in North Wales, the majority occurring in older children [3], as were the cases in Fife, Scotland in 1991–2 [4].

Children in these age groups should have received measles vaccine between 1979 and 1983. The reported coverage of measles vaccination for these years as summarized from Community Health Statistical returns to the Department of Health and expressed as percentages of the number of live births, however, was low (Table 1) [5]. Measles vaccine uptake rates rose only slowly from 55% to 68% in England during this period. Thus, as many as one-third to one-half of secondary school children remained unvaccinated. Previous studies had shown that most of these children caught measles and were, thus, immune [6]. However, since the recent introduction of MMR vaccine and the further decline in measles incidence, there has been an increase in susceptibility to measles among older children as measured by antibody levels (PHLS CDSC, unpublished data).

The percentages of children immunized in the East Sussex Health Authority (HA) for these age groups was comparatively high (Table 1) and the number of notified cases of measles was low with only 28 total cases during 1990–2. However, in early January 1993, 23 cases of measles were notified to the acting consultant in communicable disease control for East Sussex HA. The first case occurred in mid-December and most of the notifications were in teenage children attending the same school. As new cases continued, the investigation described here was conducted to elucidate the epidemiological, clinical and laboratory features of the outbreak. Further studies on the detection of measles-specific IgM and IgG antibodies in saliva in such outbreaks will be reported elsewhere.

METHODS

Criteria used in the epidemiological investigation

Case definition

Suspected cases included all children reported from physicians and school sources with a fever accompanied by a measles-like rash prior to the collection of confirmatory data and laboratory tests. A clinical case of measles was defined as

a person with a history of fever (> 38·3 °C if measured) with rash for 3 or more days, and either cough, coryza or conjunctivitis. These criteria are used by the US Centers for Disease Control and Prevention in the United States for measles surveillance and outbreak investigations [7]. A measles case was considered sero-confirmed if measles-specific IgM antibody was detected in sera. For the school study, all cases meeting the measles case definition were analysed further.

Case ascertainment

Methods used to ascertain the total number of cases of measles in the area included a survey of all general practitioners (GPs); questioning of all school nurses with follow-up of children who were absent from the school with suspected measles; and a survey of the total school population at the school which had been particularly affected. A covering letter and short questionnaire were sent to the parents of students asking for information on recent illness with a rash and fever. Details of immunization history and past history of measles were also sought. Questionnaires were sent to 1553 of the school population of 1673: 120 advanced level students were taking examinations and were not sent questionnaires.

Descriptive epidemiology

Information on all suspected cases was collected including data on patient's address, age, sex, date of onset of rash, date the illness was reported and name and address of the GP. In addition, a more detailed questionnaire was used to obtain more complete information on all suspected cases attending the school. Questions included details on demographic characteristics, the range of symptoms, date of onset and duration of rash, severity of the illness, and history of immunization or past infection.

Levels of immunization

The initial questionnaire which was sent home to the parents of all pupils at the school requested information on a history of recent or past measles infection, and current measles immunization status. This information was analysed to determine the level of knowledge parents had about their child's immunization status, in order to compare the percentage immunized in this particular group with the uptake for the region as a whole for the same time period. Verification of the immunization histories of the suspected cases at the school was carried out by review of GP records.

Virological laboratory studies

A special clinic was held at the school on the 2 February, 1993, and all the suspected cases were invited to attend. Salivary specimens and finger prick capillary tube samples of blood collected on felt paper were taken from the pupils for whom consent had been given. These samples were sent to the Virus Reference Division, Central Public Health Laboratory where they were tested for measles-specific IgM and IgG, rubella-specific IgM and parvovirus-specific IgM, using previously described methods [8, 9].

RESULTS

Epidemiological investigation

Total outbreak; cases

A total of 96 suspected cases of measles were identified: 66 attended the original affected school, 23 attended other schools and 7 were among adults and infants. The majority of suspects were in persons aged 11–17 (78%), 2 cases occurred in infants < 1 year of age and 8 cases in adults aged 18 years or over.

The epidemic curve for the school and community suspect cases showed the date of onset of the first recognized school case to be 5 December and the first community case to be 6 December, 1992 (Fig. 1). Cases continued to occur until 7 February, 1993, and community cases generally occurred later than the school ones.

Description of the school outbreak

Sixty-six suspected cases occurred among children in the school population: 37 (56%) were aged 11–14 years, 26 (39%) were 15–17, 1 was 10 and 2 were 18 years of age.

Sixty (91%) questionnaires were completed on the 66 suspected cases in the school. Of the 60, 56 (93%) were analysed further. Of the 4 excluded from analysis, 1 had recent rubella infection confirmed by laboratory tests, 1 had no measles-specific IgM and IgG in a convalescent serum sample and 2 did not meet the clinical criteria.

Of the 56 cases meeting the case definition criteria, the first occurred on 9 December and the last on 2 February (Fig. 2). The school epidemic curve suggested the occurrence of multiple generations of cases, with 7 cases occurring between 8 and 14 December, 35 between 18 and 31 December and the remainder scattered between 1 January and 2 February.

The symptoms of the 56 cases included the usual clinical manifestations of measles: 100% had rash and fever, 78% cough, 73% conjunctivitis, 69% headache and 61% coryza, 57% swollen glands, and 24% earache. Symptoms were similar, but slightly fewer in the 16 immunized compared with the 36 unimmunized students (Table 2). In 42 of the cases the rash started on the head. Two patients were hospitalized and 51 stayed in bed from 1 to 14 days.

The distribution of the cases in the school showed no significant differences by House. A larger number of cases occurred in the lower years. However, a number of pupils in the higher years (120) were sequestered in examinations and did not receive any questionnaires. Forty-six pupils consulted their GP and were told they had measles, but only 24 (52%) of these cases were notified to the health authority. The remainder were detected during active surveillance. Eighteen (32%) cases were reported as having had measles in the past.

The history of immunization was compared using the level of parents' knowledge of immunization with documented evidence of immunization in the GP records. Parents gave a positive history of immunization in 11 (20%) of 56 cases, 3 gave day, month and year, 1 gave year only, and 7 gave no date. A total of 16 cases had documented evidence (including day, month and year) of measles immunization in GP records. Of these 16, 1 had been immunized at 11 months of age, 4 at 12–14 months of age and 11 at $\geqslant$ 15 months of age. There was agreement

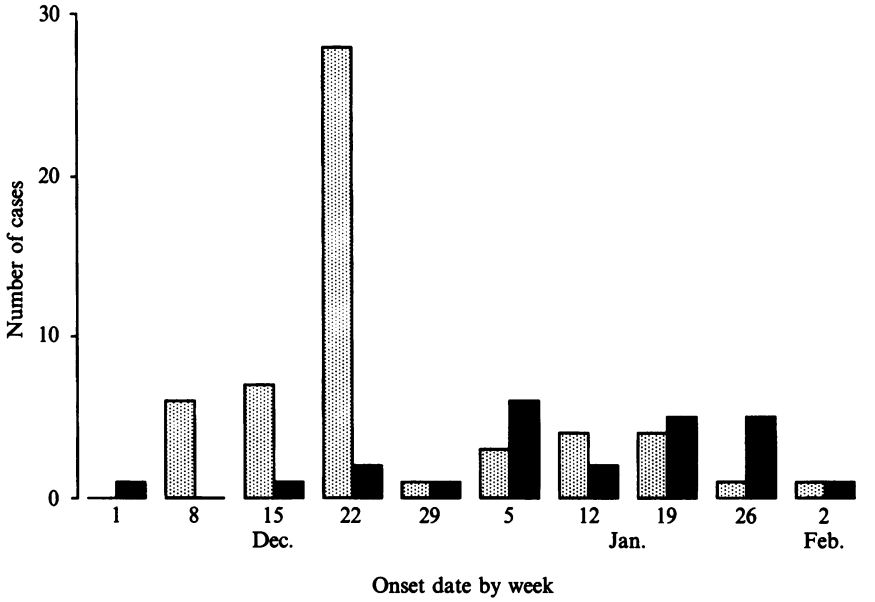

Fig. 1. Epidemic curve of measles cases East Sussex HA, Dec. 1992–Feb. 1993 (the school and community cases). ▨, School cases; ■, community cases.

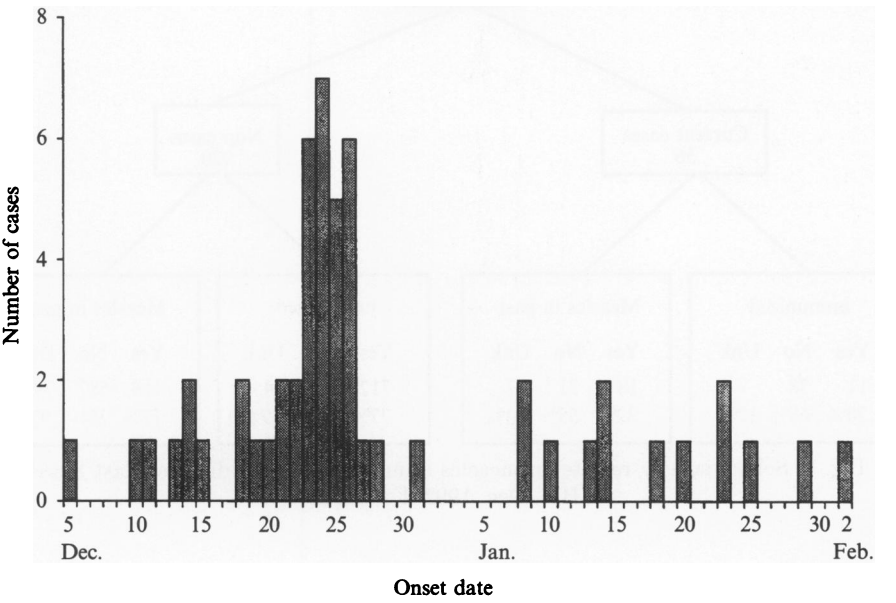

Fig. 2. Epidemic curve of measles cases at the school East Sussex HA, Dec. 1992–Feb. 1993.

in 8 cases between parental history and documented evidence in the GP records, while 8 other children had actually been immunized against measles and their parents did not know or incorrectly stated that they had not been immunized. The GP records showed that of the 7 parents who gave a history of immunization in their children (but no date), only 4 had been immunized against measles.

Table 2. *Distribution of reported symptoms between immunized and non-immunized school cases, East Sussex HA measles outbreak, December 1992 to February 1993* (n = *52*)

	Immunized (n = 16)		Non-immunized (n = 36)	
Symptoms	n	%	n	%
Fever	16	100	36	100
Cough	9	56	30	86
Red eyes	9	56	28	78
Runny nose	8	50	22	63
Headache	12	75	26	72
Swollen glands	9	56	20	57
Koplik spots	3	19	11	31
Earache	3	19	9	25

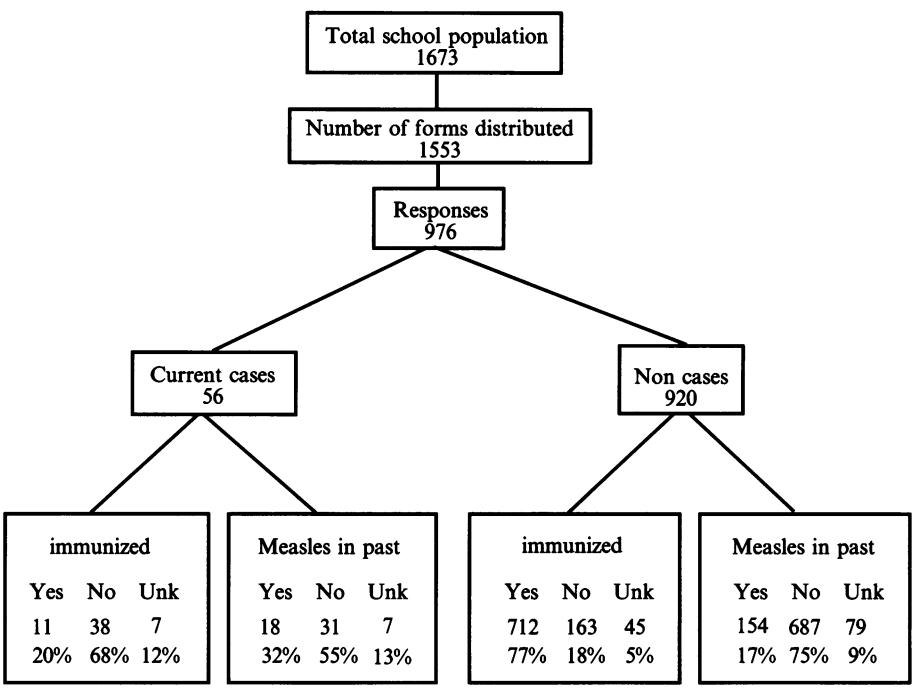

Fig. 3. School survey results on measles immunization and disease, East Sussex HA, Dec. 1992–Feb. 1993.

School survey

Of the 1553 forms sent to the school children, 976 (63%) were returned. Among the 56 cases, 11 (20%) had a history of previous immunization, 38 (68%) gave a history of no immunization and 7 (12%) did not know. Among the 920 non-cases, 712 (77%) had a history of previous measles immunization, 163 (18%) gave a history of no immunization and 45 (5%) did not know (Fig. 3). The overall reported immunization rate of 74% was comparable with what could be expected for the age group based on previous community health statistical returns for vaccine uptake for the Eastbourne HA (Table 1). [5]. There were no statistically significant differences in attack rates by age, class and house (Table 3).

Table 3. *Attack rates by age, class and house, East Sussex HA measles outbreak, December 1992 to February 1993*

Factor	No. of pupils ($n = 1673$)	No. of responses ($n = 976$)	No. of cases ($n = 56$)	Attack rate per 100
Age				
11	175	129	6	3·4
12	322	223	12	3·7
13	270	198	9	3·3
14	275	173	7	2·5
15	228	120	7	3·1
16	200	99	10	5·0
17	149	33	4	2·7
18	54	1	1	1·9
Class				
7	294	206	12	4·1
8	313	232	14	4·5
9	275	185	7	2·5
10	250	166	6	2·4
11	235	101	7	2·9
12	182	85	7	3·8
13	124	1	3	2·4
House				
A	434	257	17	3·9
N	406	270	14	3·4
I	417	219	12	2·8
S	416	230	13	1·2

Vaccine efficacy

Vaccine efficacy was estimated using immunization data provided by parents on cases and non-cases from the school survey and the formula [10]:

$$VE = \frac{ARU - ARV}{ARU} \times 100,$$

where VE = vaccine efficacy, ARU = attack rate in the unimmunized population, and ARV = attack rate in the immunized population. Using data from the 63% of the school population which responded to the survey, gave an attack rate of 0·015 (11/723) in the immunized and 0·189 (38/201) in the unimmunized for a vaccine efficacy of:

$$VE = \frac{0{\cdot}189 - 0{\cdot}015}{0{\cdot}189} \times 100 = 92{\cdot}1\,\%.$$

If GP immunization data were substituted for cases, the estimated efficacy changed only slightly as follows:

$$ARV = 16/728 = 0{\cdot}022$$

$$ARU = 36/199 = 0{\cdot}181$$

$$VE = \frac{0{\cdot}181 - 0{\cdot}022}{0{\cdot}181} \times 100 = 87{\cdot}8\,\%.$$

Table 4. *Symptoms of IgM positive and negative cases, East Sussex HA measles outbreak, December 1992 to February 1993 (n = 41)**

	IgM positive ($n = 18$)		IgM negative ($n = 23$)	
Symptoms	*n*	%	*n*	%
Fever	18	100	23	100
Rash	18	100	23	100
Cough	16	89	16	70
Red eyes	16	89	13	57
Runny nose	11	61	19	83
Headache	10	59	14	61
Swollen glands	9	53	15	65
Koplik spots	6	33	6	26
Earache	5	28	5	22

* Seven additional results were equivocal.

Table 5. *Serum IgM positivity by interval from onset to specimen collection East Sussex HA measles outbreak, December 1992 to February 1993*

Interval (days)	IgM positive ($n = 18$)	IgM negative and equivocal ($n = 30$)	Percent positive
0–21	6	2	75
22–35	2	3	40
36–45	9	17	35
> 46	1	8	11

χ^2 For linear trend = 7·02; $P = 0·0086$.

Virological investigation

Of the 52 students tested, 4 were excluded from analysis: 2 who did not meet the clinical definition, 1 with laboratory evidence of recent rubella and 1 who was seronegative for measles antibody. No IgM specific to parvovirus B19 was detected in sera collected from these cases. Of the remaining 48, 18 were positive for measles-specific IgM. Symptoms were similar among the IgM positive and negative cases (Table 4). The mean number of days between the date of the rash onset and the serum specimen collection was 36 days with a median of 39 days. A review of IgM measles-specific results by interval between date of onset and date of specimen collection showed higher rates of IgM positivity in samples taken less than 39 days (57%) than for those taken between 40 and 55 days (22%) after onset of illness ($\chi^2 = 4·74$, $P = 0·03$). In addition, there was a trend of decreasing IgM positivity with time (Table 5). Measles-specific IgM was detected in only 2 of 7 (28%) previously vaccinated cases investigated within 39 days on onset.

Initial control measures

In view of concerns about the continuing spread of measles in the school age population, the following control measures were agreed by the outbreak team [11].

1. A letter of information was sent to parents of all students attending the

school, encouraging them to have previously unimmunized children immunized against measles.

2. Notifications were sent to all GPs and a meeting was held with the doctors of the main practices involved in the outbreak to update them on the numbers, and to encourage them to immunize previously unimmunized children.

3. A press release was issued by the Director of Public Health, alerting the community to the problem and emphasizing the need for immunization.

DISCUSSION

This outbreak of measles affected over 90 persons during a 3-month period resulting in significant morbidity, loss of school-time and 2 hospitalizations. The majority of cases occurred in a local school, with a smaller number occurring in the community and at other schools. Most cases occurred in teenagers who had not previously been immunized.

This is one of several recent outbreaks of measles in school age children which have been reported in England, Wales and Scotland [2, 4, 5]. Like the other outbreaks, the majority of cases occurred in unimmunized children who were in the cohorts of children born between 1977 and 1983 and immunized during 1979–85 when immunization uptakes were low (e.g. 64–84% in East Sussex) [3]. The continuation of cases in these age groups, combined with the decline seen in fully immunized younger children, is leading to a shift in the epidemiology of measles toward older children which is reflected in local and national statistics [2, 12, 13].

The multiple generations of measles cases seen within this school community was typical for school based outbreaks. The early clustering of cases between 8 and 14 December followed by a larger clustering between 18 and 31 December most likely represents the first and second generations of cases, suggesting that the index case was missed. Earlier diagnosis and reporting (notifications were received on only half the cases and often up to a month after onset) would have allowed earlier implementation of an immunization campaign which could have reduced the number of generations and extent of spread within the community.

Sixteen school cases occurred among previously immunized children, but occurrence of some cases in previously immunized children would not be unexpected given the anticipated 95% rate of protection produced by a single vaccine [13]. In addition, 1 case had been immunized at 11 months of age and 4 at 12–14 months, ages which have been shown to have higher rates of vaccine failure [14]. Overall vaccine efficacy could only be estimated using data provided by parental histories from a school survey limited by a response rate of only 63%. However, the parents who responded to the survey reported a 74% rate of prior immunization which is consistent with expected uptake rates given the documented vaccine uptake of 64–84% in the age groups forming the cohort [3]. The accuracy of parental histories of immunization was assessed in the 56 cases where GP records were available for checking. Some misclassification was noted as only 8 (73%) of the 11 parental histories of immunization could be confirmed and 8 (18%) of the initial 45 without parental vaccine histories were found to have had measles immunization. As was the case in other studies the inability of parents to

give a specific date of immunization proved to be an indication of non-immunization [14] (noted in all 3 cases where parental histories could not be validated).

This potential for misclassification and the incomplete data for the entire population require that caveats be placed on the estimated vaccine efficacy. However, the 92% estimate was consistent with other studies [15] and would not be altered much if misclassification estimates from the GP case review were applied to the entire sample.

The laboratory investigation confirmed measles as the cause of many cases in this outbreak and indicated that 2 cases were not due to measles. The relatively low detection rate of measles-specific IgM in serum is of interest. It is possible that there was a laboratory detection problem or the illnesses identified were not all due to measles infection. Another possibility is that some of the cases represented secondary vaccine failures, a phenomenon which has been documented in an outbreak where some sero-confirmed cases had negative IgM responses [16]. However, in view of the consistency in the clinical histories and the late investigation of the outbreak, it is most likely that the low measles-specific IgM results are due to late collection of samples (median 39 days between rash onset and specimen collection). IgM antibodies for measles are often detectable within 1–5 weeks after onset of rash and probably decline thereafter [8]. Consistent with this, persons with sera drawn within 39 days had higher rates of IgM positivity (57%) than those with sera drawn after 40 days (22%) ($\chi^2 = 4{\cdot}75$, $P = 0{\cdot}03$) and there was a consistent decline in positivity with time (χ^2 for linear trend = 7·02, $P = 0{\cdot}0086$). This finding reinforces the importance of early collection of confirmatory laboratory tests in suspected measles cases.

Most of the cases in this outbreak occurred among unvaccinated children and thus were preventable. Propagation occurred because the age cohort of children affected had only 64–84% rates of vaccine uptake [3] and their antibody susceptibility levels have been increasing as measles incidence has declined. However, this level of immunization uptake is much higher than the 51–68% rates seen from 1979–85 for England as a whole [3], suggesting that similar outbreaks will continue for years unless further action is taken. As a minimum, health authorities should immunize older non-immunized children as recommended by Department of Health guidelines [11]. Once all children have received one measles immunization, consideration should be given to offering a second dose in order to achieve the World Health Organization's target of elimination of indigenous measles by the year 2000 [17]. At least 10 countries in Europe and the United States have already found it necessary to adopt such a two-dose measles vaccine policy [18].

Recommendations developed in response to this outbreak included the following

1. Early and prompt reporting of measles cases is needed so that immunization control measures can be initiated in a timely fashion.

2. During a school outbreak of measles, all children without documented histories of immunization should be vaccinated. School immunization clinics should be considered as an adjunct to GP immunization.

3. Health authorities where measles immunization coverage has been low in the

past should immunize older non-immunized children according to the Department of Health guidelines [11].

4. Primary prevention of cases is of maximum importance and this is best achieved by maintaining high vaccine uptake. Every effort should be made to improve availability of MMR vaccines to the public with accessible and frequent clinics.

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